

WHAT IS CLAIMED IS:

1                   1.       A method for determining channel estimates at a receiver for a wireless  
2 communication system using orthogonal frequency division multiplexing (OFDM) over a  
3 plurality of OFDM subcarriers, the method comprising:

4                   receiving training signals from one or more receive antennas;  
5                   computing an estimated channel impulse response from the received training  
6 signals by reference to a training sequence; and  
7                   adaptively truncating the estimated channel impulse response in the time  
8 domain to improve the signal-to-noise ratio of the channel estimates.

1                   2.       The method of claim 1, wherein computing the estimated channel  
2 impulse response includes:

3                   transforming time-domain samples of the training signals to subcarrier  
4 coefficients for each of the plurality of OFDM subcarriers;  
5                   converting the subcarrier coefficients to impulse coefficients using a training  
6 sequence; and  
7                   transforming the impulse coefficients to obtain the channel impulse response  
8 estimate in the time domain.

1                   3.       The method of claim 2, wherein the training sequence includes a zero  
2 component for a DC one of the plurality of OFDM subcarriers, and wherein converting the  
3 subcarrier coefficients to impulse coefficients includes interpolating the impulse coefficients  
4 for the OFDM subcarriers other than the DC subcarrier, thereby supplying an impulse  
5 coefficient at DC.

1                   4.       The method of claim 2, wherein the training sequence includes a zero  
2 component for a DC one of the plurality of OFDM subcarriers, the method further  
3 comprising:

4                   subsequently to transforming the impulse coefficients to obtain the channel  
5 impulse response estimate in the time domain, estimating a DC offset from a plurality of  
6 samples near the tail of the time domain channel impulse response estimate; and  
7                   correcting the time domain channel impulse response estimate for the  
8 estimated DC offset.

5. The method of claim 1, wherein adaptively truncating the estimated channel impulse response includes:

- computing a channel power function representing power received near a sample time;
- estimating channel noise;
- computing a cutoff time based on the channel power function and the channel noise estimate;
- truncating the time domain channel impulse response estimate at the cutoff time; and
- transforming the truncated time domain channel impulse response estimate to a frequency domain channel estimate.

6. The method of claim 5, wherein the channel power function is given by:

$$P_h[t] = \sum_{i=0}^{i_0} \sum_{n=0}^{M_r-1} \left| \hat{h}_n^0[(i+t) \bmod N] \right|^2, \text{ where:}$$

$t$  is a time parameter measured in samples;

$M_r$  is the number of receive antennas;

$\hat{h}_{n0}[i]$  is the time domain channel impulse response estimate;

$N$  is the number of samples in a symbol period of the training sequence; and

$i_0$  is a filtering time.

7. The method of claim 6, wherein the channel noise is estimated by minimizing  $P_h[t]$  over the time parameter  $t$ .

8. The method of claim 5, wherein truncating the time domain channel impulse response estimates includes applying a windowing function around the cutoff time.

9. The method of claim 5, wherein truncating the time domain channel impulse response estimate includes applying a timing correction determined from the channel power function.

1                    10.     The method of claim 9, wherein the timing correction is given by  
2      $\tau' = \arg \max_t P_h[t]$ , , where  $P_h[t]$  is the channel power function and the maximization is  
3     performed over all values of time parameter  $t$ .

1                    11.     The method of claim 10, wherein applying the timing correction  
2     includes cyclically shifting each of the time domain channel response estimate and the power  
3     function by  $\tau'$  samples.

1                    12.     The method of claim 1, wherein the reciever is configured to receive  
2     packets complying with IEEE 802.11a.

1                    13.     The method of claim 1, wherein the receiver includes a plurality of  
2     receive antennas and wherein the steps of receiving, computing, and adaptively truncating are  
3     performed for each of the receive antennas.

1                    14.     A method of channel estimation for a receiver of a multiple input,  
2     multiple output (MIMO) communication system wherein signals are transmitted using  
3     orthogonal frequency division multiplexing (OFDM) over a plurality of OFDM subcarriers,  
4     the method comprising:

5                    receiving, at each of a plurality of receive antennas, training signals from a  
6     plurality of transmit antennas, wherein the signal from each transmit antenna includes a  
7     different subset of the plurality of OFDM subcarriers;

8                    transforming the received training signals at each receive antenna to a plurality  
9     of impulse coefficients for that receive antenna, each impulse coefficient corresponding to a  
10    different one of the OFDM subcarriers; and

11                   for each of the receive antennas, computing a channel impulse response for  
12    one of the transmit antennas using the impulse coefficients for the subset of the OFDM  
13    subcarriers transmitted by the one of the transmit antennas.

1                    15.     The method of claim 14, wherein computing a channel impulse  
2     response for one of the transmit antennas includes:

3                    transforming time-domain samples of the training signals to subcarrier  
4     coefficients for each of the plurality of OFDM subcarriers;

5                    converting the subcarrier coefficients to impulse coefficients using a training  
6     sequence; and

7 transforming the impulse coefficients to a channel impulse response estimate  
8 in the time domain.

1 16. The method of claim 15, wherein the training sequence includes a zero  
2 component for a DC one of the plurality of OFDM subcarriers, and wherein converting the  
3 subcarrier coefficients to impulse coefficients includes interpolating the impulse coefficients  
4 for the OFDM subcarriers other than the DC subcarrier, thereby supplying an impulse  
5 coefficient at DC.

1 17. The method of claim 15, wherein the training sequence includes a zero  
2 component for a DC one of the plurality of OFDM subcarriers, the method further  
3 comprising:

4 subsequently to transforming the impulse coefficients to obtain the channel  
5 impulse response estimate in the time domain, estimating a DC offset from a plurality of  
6 samples near the tail of the time domain channel impulse response estimate; and

7 correcting the time domain channel impulse response estimate for the  
8 estimated DC offset.

1 18. The method of claim 15, wherein computing a channel impulse  
2 response for one of the transmit antennas further includes adaptively truncating the time  
3 domain channel impulse response estimate to improve the signal-to-noise ratio of the channel  
4 estimates.

1 19. The method of claim 18, wherein adaptively truncating the time  
2 domain channel impulse response estimate includes:

3 computing a channel power function representing power received near a  
4 sample time;

5 estimating channel noise;

6 computing a cutoff time based on the channel power function and the channel  
7 noise estimate;

8 truncating the time domain channel impulse response estimate at the cutoff  
9 time; and

10 transforming the truncated time domain channel impulse response estimate to  
11 a frequency domain channel estimate.

20. The method of claim 19, wherein the channel power function is given by:

$$P_h[t] = \sum_{i=0}^{i_0} \sum_{n=0}^{M_r-1} \sum_{m=0}^{M_t-1} \left| \hat{h}_{nm}^0[(i+t) \bmod N] \right|^2, \text{ where:}$$

$t$  is a time parameter measured in samples;

$M_r$  is the number of receive antennas;

$M_t$  is the number of transmit antennas;

$\hat{h}_{no}[i]$  is the time domain channel impulse response estimate;

$N$  is the number of subcarriers transmitted by one transmit antenna during the training sequence; and

$i_0$  is a filtering time.

21. The method of claim 20, wherein the channel noise is estimated by minimizing  $P_h[t]$  over the time parameter  $t$ .

22. The method of claim 19, wherein truncating the time domain channel impulse response estimate includes applying a timing correction determined from the channel power function.

23. The method of claim 22, wherein the timing correction is given by  $\tau' = \arg \max_t P_h[t]$ , where  $P_h[t]$  is the channel power function and the maximization is performed over all values of time parameter  $t$ .

24. The method of claim 23, wherein applying the timing correction includes cyclically shifting each of the time domain channel response estimate and the power function by  $\tau'$  samples.

25. A method of tracking channel variations during receipt of a packet using one or more receive antennas, comprising:

determining an initial channel estimate from training data included in the packet;

identifying a received symbol in the packet;

estimating an input symbol value using the received symbol value and the initial channel estimate;

8                    deriving a per-symbol channel estimate from the received symbol value and  
9 the estimated input symbol value; and  
10                    updating the initial channel estimate using the per-symbol channel estimate.

1                    26.     The method of claim 25, wherein updating the initial channel estimate  
2 includes applying a first order filter to the initial channel estimate and the per-symbol channel  
3 estimate.

1                    27.     The method of claim 25, wherein the packet is transmitted using a  
2 plurality of transmit antennas and received using a plurality of receive antennas, and wherein  
3 channel estimates are derived as a matrix for respective channels between each of the  
4 transmit antennas and each of the receive antennas.

1                    28.     The method of claim 25, wherein the packet is transmitted using  
2 orthogonal frequency division multiplexing (OFDM) over a plurality of OFDM subcarriers  
3 and wherein channel variations are tracked for each of the OFDM subcarriers.